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. . . for Forestland Managers and Others Interested in Stewardship of the Forest Resource.

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Issues 17, 18, 19, and 20 of the Forest Management Update can be viewed at the following Website:

http://www.fs.fed.us/na/morgantown/frm/perkey/fmu/fmutoc.htm

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Cover Picture: *The Coopers Rock Crop Tree Demonstration Area has been used to show how managing crop trees can produce multiple benefits for landowners. Some visitors openly express their excitement about the concept.*

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NORTHEASTERN AREA
State and Private Forestry

A Decade at a Crop Tree Demonstration Area

by

Arlyn W. Perkey and Amy Onken

The Coopers Rock Crop Tree Demonstration Area was established in 1989 as a cooperative venture between the West Virginia Division of Forestry and the USDA Forest Service, Northeastern Area State and Private Forestry, and the USDA Forest Service, Northeastern Research Station. Located at Coopers Rock State Forest, near Exit 15 of Interstate 68 in northern West Virginia, it serves as an outdoor observation opportunity for foresters, wildlife biologists, and landowners interested in applying crop tree management on the non-industrial private forest.

Measured tree responses and photographic documentation of changes have been a critical resource for explaining the benefits of crop tree management to audiences. Over 10 years of annual growth measurements on selected individual trees across 10 acres are the basis for the following results. Periodic area-wide timber inventory measurements were also made, primarily for the purpose of allowing foresters to observe how trees respond to crop tree management prescriptions as measured by traditional area-wide inventory procedures.

SITE AND STAND DESCRIPTION

The treatment area is on a gentle south-facing slope, described as Site Class 4 (Dry), in *Using Diagnostic Plants To Evaluate Site Class*. The control is on a more mesic, north-facing slope on the opposite side of a dividing ridge. The more mesic conditions in the control are reflected in the larger average size of the largest five red oak/yellow-poplar crop trees per acre in this even-age stand. On the south side of the ridge, the largest five trees average 17.6 inches dbh diameter at breast height), while on the north side they average 19.8 inches—a 2.2 inch differential in 55 years. While it would be beneficial to have all treatment areas and the control on land with identical site productivity, if it is not identical, it is critical that the control be located on the more productive site. This assures that any greater growth observed in the treatment areas will not be because of site productivity. This variation in site means the increased growth on the treatment areas compared to the untreated control is conservative. If the sites were identical, the difference would be even greater.

The stand is mostly even-age, originating after clearcutting. Fires were controlled by 1934 when the property came into state ownership. Yellow-poplar and red oak are the predominant species in the overstory, with a few black cherry scattered throughout the stand. On the poorest microsites, chestnut oak and white oak are present in the main crown canopy. Most of the larger white oak is older than the other species in the stand. Apparently these larger trees were unmerchantable poles left after the last harvest that survived post-harvesting ground fires.

WHAT WAS DONE

Between January and April of 1989, individual crop trees were released on three two-acre crop tree management prescription areas. Intensity of treatment varied and is reflected by the number of crop trees released per acre; maximum (32 crop trees/acre), moderate (25 crop trees/acre), and minimum (21 crop trees/acre). Prescriptions on these three areas varied from timber only as an objective; to

The first growing season following release, this red oak timber and wildlife crop tree in the moderate treatment area is taking advantage of the additional growing space around its crown.

Looking at the same tree seven growing seasons later, we notice the slash from the harvesting operation is deteriorated and midstory trees are developing a closed subcanopy.

timber and wildlife; to timber, wildlife, and aesthetics. Additionally, a 2-acre area-wide thinning and 2-acre control were established to compare to the crop tree management prescriptions.

Cut trees were felled and moved to a landing by the USDA Forest Service logging crew from the Fernow Experimental Forest near Parsons, West Virginia. The West Virginia Division of Forestry sold the stockpiled timber products. After the harvesting was completed, a trail through the treatment areas was constructed with numbered posts at periodic points of interest. A trail guide was published to explain the treatments to visitors. Annual measurements at diameter breast high on crop trees and selected comparison trees were made during each dormant season to contrast annual growth by species and free-to-grow rating.

WHAT WAS DEMONSTRATED – HOW FAST CAN INDIVIDUAL TREES GROW?

Variation in Annual Crop Tree Growth

A set of 10 red oak and 10 yellow-poplar released crop trees were monitored and growth was compared to 10 similar unreleased trees and partially released trees in the control and area-wide treatment areas. Results indicate wide variation in annual growth. The following table and charts show that released

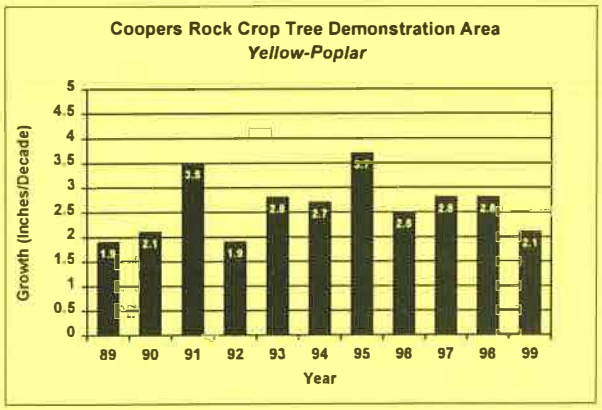
Coopers Rock Crop Tree Demonstration Area

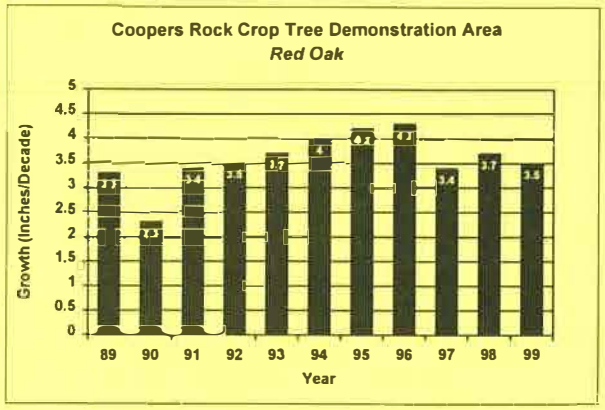
Comparison of Crop Tree Growth Rates

Based on 11 years of measured DBH growth (1989-1999) of 10 trees with similar initial diameters in a control, an area-wide thinning, and a crown-touching release applied to individual crop trees.

		Average 1988 DBH	Average Annual Growth Rate (In./Decade)											Ave. Growth (In./Decade)	Average 1999 DBH
			89	90	91	92	93	94	95	96	97	98	99		
	YELLOW-POPLAR														
	CONTROL	15.3	1.6	0.5	2.2	0.8	1.5	1.0	2.6	0.8	1.7	1.8	1.5	1.5	16.9
	AREA-WIDE	15.6	1.0	1.7	3.0	1.1	2.0	2.0	2.9	1.4	2.1	2.6	1.5	1.9	17.7
*	CT RELEASE	15.4	1.9	2.1	3.5	1.9	2.8	2.7	3.7	2.5	2.8	2.8	2.1	2.6	18.3
	RED OAK														
	CONTROL	15.2	2.0	1.8	2.0	2.0	2.5	1.6	3.0	1.7	1.9	2.4	1.6	2.0	17.4
	AREA-WIDE	15.1	2.2	1.6	2.5	2.3	3.2	2.5	2.8	2.7	1.9	2.8	2.2	2.4	17.8
*	CT RELEASE	15.2	3.3	2.3	3.4	3.5	3.7	4.0	4.2	4.3	3.4	3.7	3.5	3.6	19.1

* Annual growth shown in bar graph





red oak and yellow-poplar trees grow almost twice as fast as unreleased trees during the better growing seasons. Presumably this is largely a weather influence. However, the later growing seasons may also be influenced by a reduction of free-to-grow space caused by closing of the crown canopy. Wide growth rate fluctuation of unreleased yellow-poplar (in the control) among seasons suggests that trees affected by crowding from competitors have greatly impaired growth when weather is less favorable.

The absolute growth rate for red oak is better than for yellow-poplar on this site at this age. The rapid height and diameter growth rate of yellow-poplar early in the life of the stand resulted in a larger average diameter for yellow-poplar crop trees when compared to red oak crop trees. However, by age 55 this size dominance was reversing because of the more rapid growth rate of red oak on this site at this stage of stand development. In 1989, prior to any treatment, the average size of the five largest red oaks and five largest yellow-poplars was compared for each of the 5 two-acre plots in the demonstration area. In 1989, in all five plots, the five largest yellow-poplars were larger than the five largest red oaks. In 1998, in the four plots that were treated, size dominance between the two species was reversed. The five largest red oaks were larger than the five largest yellow-poplars. In the untreated control, that change in size dominance had not yet occurred, but was strongly trending that way. The size differential between the two species in the control dropped by 40 percent during the 10-year period.

The following graphics charting the annual released crop tree growth with the unreleased control comparison trees shows the relationship of the same set of ten released and unreleased red oak and yellow-poplar crop trees. On average, released yellow-poplar grew 73 percent faster than comparison trees in the control while released red oak grew 80 percent faster than comparison trees.
The shift in size dominance between species is not limited to the largest trees. The following table shows the average size of 50 released red oak crop trees in 1989 and 1998, compared to the average size of 76 released yellow-poplar trees in the same years.

Average Size of Crop Trees in Treatment Areas

SPECIES	1989 dbh	Growth	1998 dbh
Red oak	14.5 inches	3.3 inches	17.8 inches
Yellow-poplar	14.9 inches	2.7 inches	17.6 inches

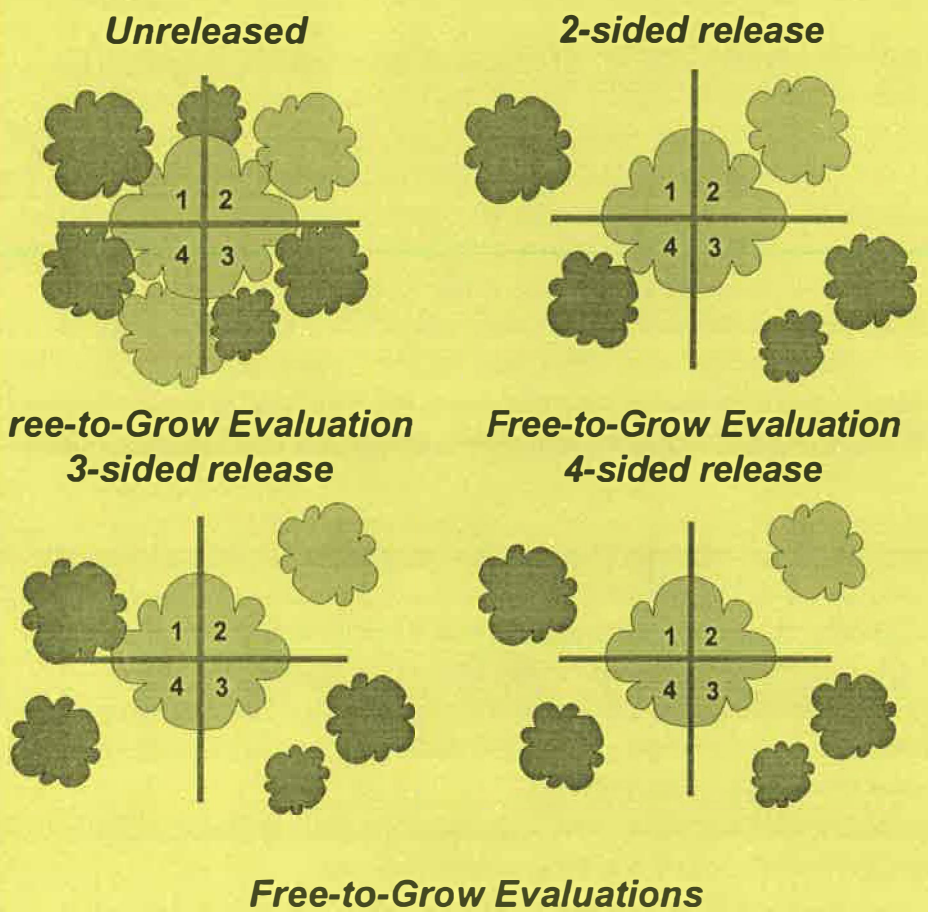
For the unreleased trees in the control the relative size of 20 potential red oak crop trees and 45 potential yellow-poplar crop trees is as follows:

Average Size of Potential Crop Trees in Control Area

SPECIES	1989 dbh	Growth	1998 dbh
Red oak	15.3 inches	2.1 inches	17.4 inches
Yellow-poplar	16.9 inches	1.6 inches	18.5 inches

The greater site productivity in the control is reflected in the larger initial size of potential crop trees in the control compared to the crop tree treatment areas. This difference in productivity is probably advantageous to yellow-poplar on this site. However, even on this site, at this age, the red oak has grown faster during the most recent 10-year period. While the red oak has not yet surpassed the yellow-poplar in average potential crop tree size, it is gaining on it.

The CTM concept is based on providing a full crown-touching release to selected crop trees. Essential to the success of this system is Free-to-Grow (FTG) evaluation.

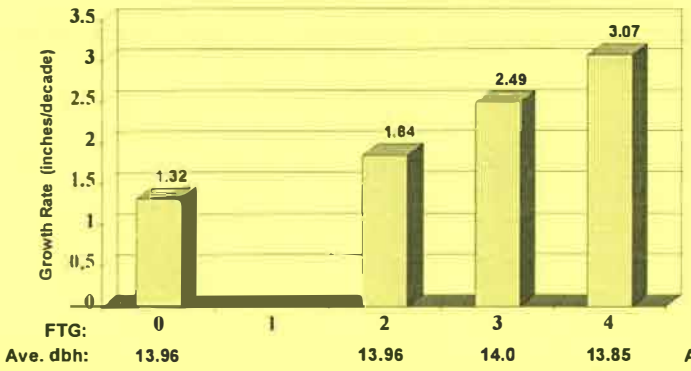


Free-to-Grow Evaluations

To evaluate a crop tree's free-to-grow status, imagine its crown in quadrants. If competitor trees are not "crown-touching," the crop tree is free-to-grow in that quadrant.

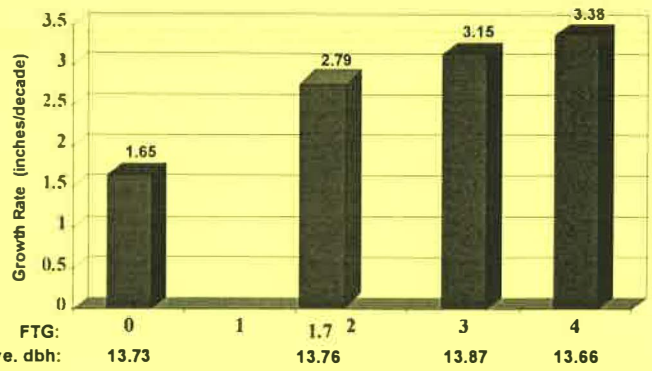
For yellow-poplar and red oak, growth by free-to-grow status was evaluated using sets of 10 released and unreleased trees. In the case of red oak there was not a sufficient number of available 2-sided released trees, so three 1-sided released trees were used to have a set of ten. On the graphic this is shown as an average free-to-grow status of 1.7. The following graphics show that generally on this site with this initial average size, it is a linear relationship between free-to-grow status and growth rate for these two species of this age.

Yellow-Poplar Growth Rates by Free-to-Grow Rating (1989)



Average dbh for sets of 10 trees by free-to-grow rating

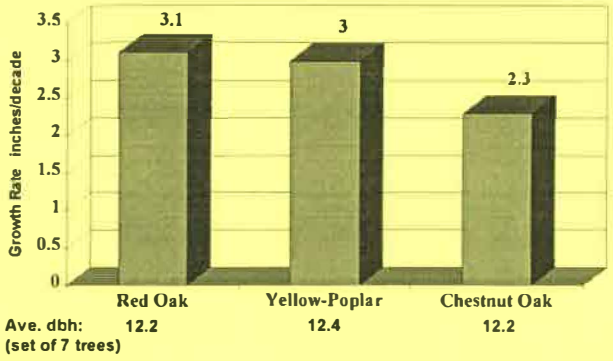
Red Oak Growth Rates by Free-to-Grow Rating (1989)



Average dbh for sets of 10 trees by free-to-grow rating

The above information clearly indicates that on average, for trees of theses species of this age on this site, as the degree of release of individual trees increases, the growth rate increases.

Released Chestnut Oak Growth Rate Comparisons (1989)



Growth Rate of Chestnut Oak

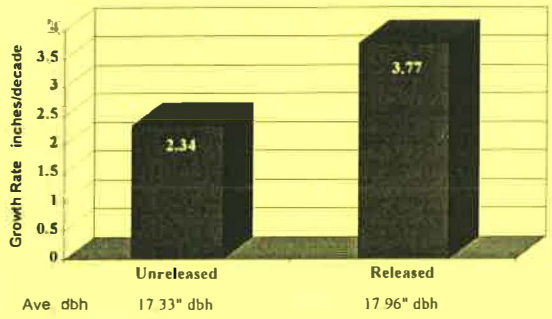
The number of chestnut oak trees on the area was not sufficient in the control to compare released and unreleased growth rates. However, seven released chestnut oaks do provide some indication of how this species performs on this site. The average size of chestnut oak crop trees in the stand was slightly over 12 inches dbh in 1989. This is smaller than the average size of red oak (14.5 inches) and yellow-poplar (14.9 inches), reflecting the slower growth rate for this species during the initial 5.5 decades of growth. Average tree growth for adequately released trees is about 2.3 inches per decade, with variation from 1.4 to 2.7.

When growth of these seven released chestnut oaks was compared to the growth of seven yellow-poplar and red oak of similar initial size, the influence of species on growth rate for trees of this size and age became apparent. Red oak and yellow-poplar trees that have similar average sizes (12.2 and 12.4 inches dbh) have greater average growth rates (3.1 and 3.0 inches per decade), with per tree variation from 2.3 to 4.1 inches per decade.

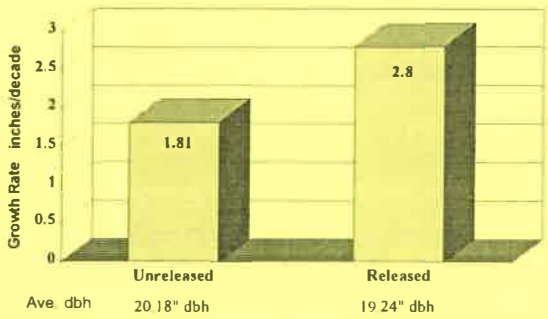
Growth Response of Dominant Trees

To evaluate the growth response of the largest, dominant crop trees, the growth of the 10 largest released red oaks and yellow-poplars in the 6-acre crop tree release treatments is compared to the 10 largest unreleased trees in the control.

Comparison of 10 Largest
Unreleased and Released Red Oak



Comparison of 10 Largest
Unreleased and Released Yellow-Poplar



Growth response on these largest trees is 60 percent for red oak and 55 percent for yellow-poplar. While that is somewhat less than the 80 percent and 73 percent response rates for medium-sized crop trees, it is still a very positive indication that forest-grown dominant trees of this species and age are able to enlarge their crowns and accelerate growth.

WHAT WAS DEMONSTRATED – HOW MUCH DO INDIVIDUAL TREES EARN?

The diameter-at-breast-height growth of individual trees expressed as growth in inches per decade is a simple, easily monitored means of measuring how trees are performing. However, sometimes it is desirable to convert that physical growth into financial terms to compare the trees' performance to other investment opportunities. This conversion from a physical growth rate to a financial rate of return and annual income per tree does complicate comparisons. The results are very much dependent on assumptions made regarding factors such as stumpage prices, inflation, and changes in unit value related to size and quality of the timber products (grade) that can be produced from the trees.

The following financial analysis is based on these assumptions:

- Tree volumes were estimated using an approximation of the International Tree Scale. This volume was converted to a Doyle Tree Scale estimate using diameter class conversion factors. This conversion was made because stumpage prices are reported using the Doyle Rule. Tree heights were estimated to an 8-inch top diameter inside bark.
- Timber prices are based on stumpage rates published in the West Virginia Price Report for Region II (includes Monongalia County) for 1989 and 1998. Adjustments of these prices to reflect the value of various grades were made using ratios calculated from prices found in the Pennsylvania Woodlands Timber Market Report (Southwest) for October-December, 1989 and July-September, 1998.
- For yellow-poplar, three grade (value) thresholds were recognized: Grades 1, 2, and 3. For red oak, an additional threshold, Grade 1 plus category is for trees 20+ inches dbh.

It is critical to examine the following two financial parameters when evaluating individual tree performance:

- Rate of Return – This financial parameter describes the compound rate of increase in value for an individual tree or group of trees for a given period of time. Many people compare it to the interest rate earned on a passbook account at a bank. While it adequately describes the rate of increase of an investment during a period of time, it does not describe the significance of that return for a tree or group of trees. For example, a tree that has a value of $.50 at the beginning of a 10-year period and $1.00 at the end of the period has a rate of return of 7.2 percent. A tree worth $50.00 at the beginning of the 10-year period and $100.00 at the end would also have a rate of return of 7.2 percent. The difference is the first tree earned $.50 while the second tree earned $50 during the same period.
- Annual Income – This financial parameter describes the significance of the investment for a tree or group of trees. In the above example, the first tree earns an annual income of $.05 per year, while the second tree earns an annual income of $5.00 per year.

Together, these parameters describe the desirability of the investment and provide a basis for comparison of investment alternatives.

The following two tables display for red oak and yellow-poplar average dbh growth, average rate of return, and average annual income for three sets of 10 trees with varying free-to-grow status.

Red Oak

Treatment	Ave. Initial dbh	Free-to-Grow	Dbh Growth	Rate of Return*	Annual Income
Released	15.2	3.8	3.6	19.6%	$5.42
Area-wide	15.1	2.9	2.4	16.9%	$3.77
Unreleased	15.2	0.1	2.1	16.2%	$3.59

*The increase in red oak stumpage value for this 10-year period was approximately 8.5 percent.

Yellow-Poplar

Treatment	Ave. Initial dbh	Free-to-Grow	Dbh Growth	Rate of Return*	Annual Income
Released	15.4	3.8	2.7	18.3%	$2.82
Area-wide	15.6	3.0	1.9	15.9%	$2.35
Unreleased	15.3	0.5	1.4	17.8%	$2.19

*The increase in yellow-poplar stumpage value for this 10-year period was approximately 11.4 percent.

The treatment labeled area-wide refers to potential crop trees (comparison trees) in a plot where an area-wide thinning was completed. The unreleased treatment is in the control where any free-to-grow space was because of natural mortality.

The red oak surpassed the yellow-poplar both in terms of absolute growth and financial parameter performance. This is especially true if you consider that yellow-poplar had better percentage price appreciation during the period. In other words, for released yellow-poplar trees, 11.4 percent of the 18.3 percent rate of return was because of price appreciation and the remaining 6.9 percent was because of growth and increase in unit value of the product. For red oak, 8.5 percent of the rate of return was because of price appreciation and the remaining 11.1 percent of the 19.6 percent rate of return reflected growth and unit value increase.

Comparing the difference in annual income produced on a per acre basis helps to clarify the significance of releasing crop trees versus leaving them unreleased. For this comparison, only red oak and yellow-poplar crop trees are included. On the average in this treatment area, there are eight red oak crop trees per acre and 13 yellow-poplar. The following table summarizes the influences of crop tree management on per acre income.

Annual Income/Acre for a Mixed Red Oak/Yellow-Poplar Stand with 21 Potential Crop Trees/Acre (Released vs Unreleased)

Species	Number of trees	Released Income/tree	Income per acre	Number of trees	Unreleased Income/tree	Income per acre
RO	8	$5.42	$43.36	8	$3.59	$28.72
YP	13	2.82	36.66	13	2.19	28.47
Total	**21**		**$80.02**	**21**		**$57.19**

To further consider the significance of treatment, the following table compares the released vs unreleased option at the stand level.

Periodic Income for a Mixed Red Oak/Yellow-Poplar Stand with 21 Potential Crop Trees/Acre (Released vs Unreleased)

	Stand Size	Period	Income/Acre	Income/Period
Released	25 acres	10 years	$80.02	$20,005.00
Unreleased	25 acres	10 years	57.19	14,297.50
Difference				**$ 5,707.50**

The preceding information provides a basis to estimate the financial value of crop tree management on an area of this site productivity, species composition, age, and size. If the release work is done as a part of a commercial operation, the $5,707.50 is a net benefit, and well worth doing. What landowner wouldn't want to receive 40 percent additional income as a result of a no-cost treatment? However, if the treatment requires out-of-pocket investment, how much can be invested and still break even?

The answer to that question depends on the rate used to discount the $5,707.50 back 10 years. The following table shows maximum investment per acre and per crop tree to break even at various discount rates.

Break-Even Investment by Discount Rate

UNIT	DISCOUNT RATE			
	4%	6%	8%	10%
Per Acre	$154.00	$127.00	$106.00	$88.00
Per Crop Tree	$7.33	$6.05	$5.05	$4.19

The above table indicates that if a landowner anticipates gross increases in value, similar to what was experienced at this demonstration area, treatment costs must be constrained.

The Tables in *ESTIMATING COSTS FOR PRECOMMERCIAL SILVICULTURAL TREATMENTS IN THE NORTHEAST,* in this issue of the Forest Management Update, were used to estimate the cost of doing this release work in the moderate release treatment area where 25 crop trees were released per acre by removing 72 square feet of basal area. Cost approximations vary depending on assumptions made regarding how the work would be done. However, $140/acre is a reasonable estimate for this intensive work.

If the above assumptions are appropriate, it appears that on this site, the treatment would yield slightly better than a 4 percent rate of return. If cost sharing from non-landowner funds is available to invest in the benefit of having a high-quality, high-value timber product available for use, the return to the landowner can be improved.

Another way to reduce the cost of investment is to release fewer crop trees per acre. Releasing the red oak and very best yellow-poplar would result in lower treatment costs per acre and higher average annual incomes/crop tree.

Another means of improving the financial attractiveness of out-of-pocket crop tree management investments is to limit applications to sites of greater productivity. Not only do more productive sites have greater growth rates, they tend to have a greater number of potentially valuable crop trees per acre. As the number of desirable crop tree candidates per acre increases, the attractiveness of the investment increases.

AREA-WIDE STATISTICS

While the intent of the Coopers Rock Crop Tree Demonstration Area is to show the benefit of focusing treatment on individual crop trees, foresters are usually interested in the effect of the treatments on commonly used area-wide parameters like basal area and relative stand density. The following chart shows the basal area and relative stand density of the treatment areas prior to cutting, immediately after cutting, and 10 growing seasons after releasing crop trees.

Area-Wide Statistics

BA = Basal Area in sq. ft./ac. RD = Relative Stand Density (percent)

Plot Objective	Treatment	*Pre-Harvest (January 1989)*		*Post-Harvest (May 1989)*		*After 10 Seasons (December 1998)*	
		BA	RD	BA	RD	BA	RD
Control	None	157	88			163	123
Timber only	Area-Wide Thinning	133	99	83	68	130	105
Timber only	Maximum Crop Tree Mgmt. (32 crop trees/acre released)	130	84	43	35	92 67*	138 56**
Timber & Wildlife	Moderate Crop Tree Mgmt. (25 crop trees/acre released)	132	78	60	48	117 108*	123 87**
Timber, Wildlife, & Aesthetics	Minimum Crop Tree Mgmt. (21 crop trees/acre released)	148	106	83	68	110	85

* Basal Area when ingrowth is excluded.
** Relative Stand Density when ingrowth is excluded.

The maximum and moderate crop tree management prescriptions that released the greater number of crop trees (32 and 25 crop trees per acre, respectively) provided open canopy conditions that resulted in the establishment of regeneration. When the permanently established basal area points were remeasured after 10 growing seasons, the regeneration was large enough to count on the 10 basal area factor variable radius points. The basal area and relative stand density parameters are shown both with and without this ingrowth. This shows how much of the current density is on trees that were present 10 years ago, and how much is on newly established saplings.

To most observers, reducing stand density to 43 and 60 square feet of basal area (maximum and moderate treatments) seemed like a very heavy cut immediately after treatment. After 10 growing seasons the basal area on those same trees had increased to 67 and 108 square feet, respectively. That type of rapid basal area growth (2.4 to 4.8 sq. ft./acre/year) occurred because the residual crop trees were most often the trees that had the best capability of growing and quickly expanding into available growing space. A similar growth response cannot be expected if the residual basal area consists of mostly poor quality midstory trees. That is usually what happens in typical high-grading, diameter-limit cut, "select" cut operations.

PREDICTED VS ACTUAL BASAL AREA GROWTH

Basal area growth rates for all of the treated areas exceeded the growth predicted by NE Twigs, the growth prediction model that is most appropriate for this stand species composition. The following table indicates the growth relative to what the model predicted.

Clay Smith, Northeastern Research Station (retired), discusses the crop tree management treatments with landowners, foresters, and wildlife biologists.

REGENERATION

Cutting in the treatment area provided sufficient light through the canopy to stimulate establishment of regeneration throughout much of the area. However, the species composition of the cohort was dramatically influenced by a relatively high deer population. Most of the oak, yellow-poplar, and red maple stump sprouts were repeatedly browsed and prevented from achieving a competitive height. Seedlings from these three species groups were also severely browsed.

Predicted vs Actual Basal Area Growth

Treatment/ Objective	1989	1998 Predicted		1998 Actual	
	Post-Harvest BA	BA (NE Twigs)	Increase (%)	BA*	Increase (%)
Control	158	159	0	163	3
Area-wide Thinning	83	94	13	130	56
Max. CTM/ Timber	43	52	24	67	60
Mod. CTM/ Timber & Wildlife	60	71	18	108	81
Min. CTM/ Timber, Wildlife, & Aesthetics	83	97	16	110	32

* Actual measured basal area is exclusive of ingrowth, trees that either did not exist or were less than 1-inch dbh in 1989, but were more than 1-inch dbh in 1998.

By the end of the tenth growing season, black cherry was dominating the understory where gaps in the main-crown canopy provided sufficient light, and preferential deer browsing restrained other competing tree species.

There was a black cherry seed source in the area from scattered black cherry trees in the overstory. At the time of cutting, there may have been some advanced black cherry regeneration present in the understory. Black cherry is a gap species, meaning it is able to develop in an understory where a disturbance, like cutting, opens the canopy and creates gaps for light to penetrate to the forest floor. Black cherry is relatively low on the browse preference list for deer. Consequently, black cherry seedlings established and developed into saplings. Where a significant understory has developed in the treatment area, the species composition is overwhelmingly black cherry. Unfortunately, this site is not a high-quality black cherry site. It is better suited for growing red oak, which at this time is absent from the younger age class.

When doing maximum and moderate crop tree release in 50-plus-year-old stands, it is important to consider the effect of the treatment on the understory that may develop. When evaluating the influence of the treatment on regeneration, it is critical to remember that the amount of sunlight coming through the canopy is only one factor influencing regeneration. Others include presence or absence of advance regeneration, seed source availability, the deer population, and the availability of alternative sources of food for deer in the area.

SUMMARY

Following are some highlights of things demonstrated during the past 10 years at the Coopers Rock Crop Tree Demonstration Area.

- Fifty-five-year-old, previously unthinned, red oak and yellow-poplar on a dry site in northern West Virginia responded well to 3- and 4-sided crown-touching release. Individual tree diameter growth increased by 80 percent and 73 percent, respectively, when compared to unreleased trees growing on a more productive site.
- The largest, most dominant red oak and yellow-poplar crop trees also responded to 3- and 4-sided crown-touching release, increasing growth by 60 percent and 55 percent, respectively.
- Released red oak grew faster (3.6 inches/decade) than yellow-poplar (2.6 inches/decade) on this site during this decade of stand development. This is a reversal from the earlier years as reflected in the larger initial size of yellow-poplar.
- As the free-to-grow rating increases for individual crop trees, the growth rate increases.

- The nominal rate of return for released red oak and yellow-poplar was a very acceptable 19.6 percent and 18.3 percent. The proximity of these two rates was partly because there was a greater price appreciation for yellow-poplar during the 10-year period. Annual income/released crop tree was significantly better for red oak ($5.42) than yellow-poplar ($2.82).
- When crop trees with a good potential to grow are released, they respond very well as reflected with basal area growth rates of 2.4 to 4.8 sq. ft. per acre per year, compared to .6 sq. ft./acre per year where crop trees are unreleased.
- The basal area growth of all treatments exceeded that predicted by NE Twigs.

This Demonstration has become a valuable asset, showing how the application of crop tree management on the non-industrial private forests of the Appalachian region can provide timber, wildlife, and aesthetic benefits to landowners and society. These forests produce more benefits when they are managed.

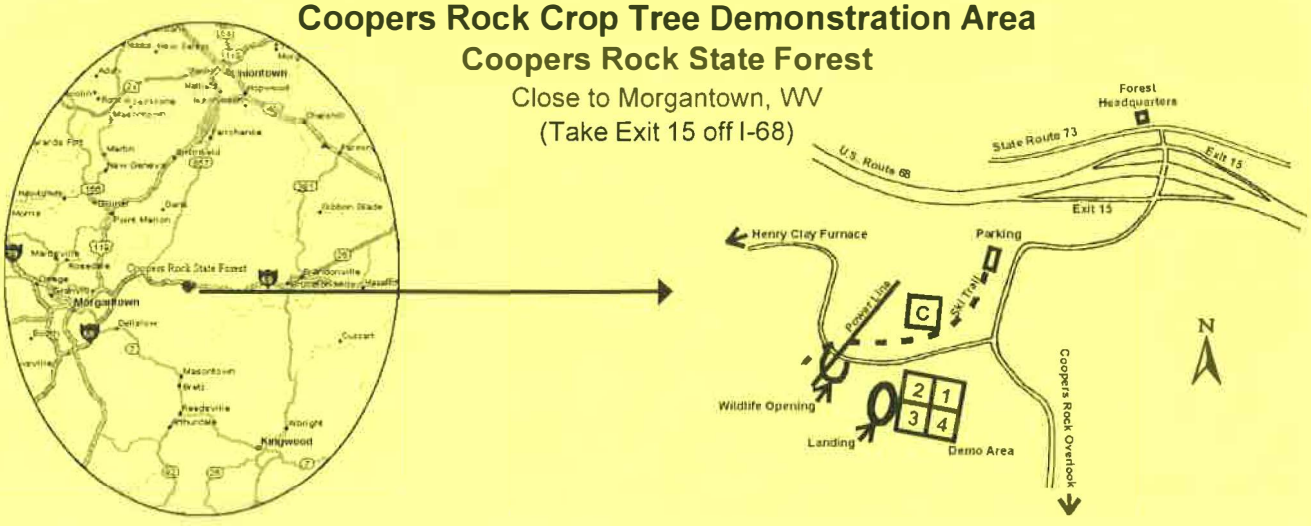
In April of 1989 the red oak in the background and yellow-poplar in the foreground were surrounded by freshly cut stumps and slash.

Ten years later, March 1998, the same red oak and yellow-poplar were respectively 3.4 inches and 3.2 inches larger in diameter. Now they are surrounded by a few residual pieces of coarse slash, and dense black cherry regeneration.

Coopers Rock Crop Tree Demonstration Area

Coopers Rock State Forest

Close to Morgantown, WV
(Take Exit 15 off I-68)



Survey of Breeding Birds at the Coopers Rock Crop Tree Demonstration Area

Summarized by
Arlyn W. Perkey

Crop Tree Management treatments can provide suitable habitat for both forest-interior and edge-tolerant species. Both groups established territories and nested within the harvested areas during the survey period.

From 1995 to 1997, breeding bird territories were drawn for forest interior and edge-tolerant species inhabiting the Coopers Rock Crop Tree Demonstration Area. Maximum (32 crop trees released), Moderate (25 crop trees per acre released), Minimum (21 crop trees per acre released) Crop Tree Management treatments resulted in a greater number of territories for both groups. Harvesting opened the canopy which allowed understory and midstory structure to develop, while the remaining crop trees provided suitable habitat in the canopy. Crop Tree Management applications were compared with a traditionally thinned treatment and unharvested (untreated) areas.

FOREST-INTERIOR SPECIES

Many forest-interior species, like this scarlet tanager, use crop trees in the main crown canopy. Free-to-grow crowns provide better viewing opportunities for bird-watching landowners.

The scarlet tanager, a particularly attractive forest-interior species to many landowners, had almost 3 times as many territories in the harvested areas as it did in the unharvested areas. Hooded warblers, black and white warblers, and American redstarts, all forest-interior species, had many more territories in the treated areas. Hooded warblers were especially abundant in the Moderate and Maximum Crop Tree Management units. Ovenbirds used the harvested areas only slightly more frequently than the unharvested areas.

The only forest-interior species with more territories in the untreated area was the black-throated green warbler. In a previous study in northern hardwoods, it showed sensitivity to heavy logging (>50% of the volume) but not light logging (<25% of the volume). In this study, the areas receiving the lightest harvesting treatments were not as desirable as the unharvested areas for this species.

For forest-interior species, few nests were found, probably because many of these species were canopy nesters and their nests are difficult to locate. Therefore, the effects of crop tree management prescriptions on nesting success could not be thoroughly evaluated. However, of the three forest-interior species nests found (2 Hooded Warblers and 1 American Redstart), two of these three nests successfully fledged young.

EDGE-TOLERANT SPECIES

As expected, edge-tolerant species were most abundant on the Maximum and Moderate Crop Tree Management treatments where dense mid-story vegetation provided their traditional nesting habitat. The wood thrush was the most common edge-tolerant species with the greatest number of territories and the most nests monitored. Nine wood thrush nests were found on the harvested plots and seven of these successfully fledged young. No wood thrush and no gray catbird nests were found in the untreated area. Nests of other edge-tolerant species monitored on the harvested plots included eastern towhee (1 nest, 1 successful), eastern wood-peewee (1 nest, 1 successful), gray catbird (3 nests, 1 successful), and red-eyed vireo (2 nests, 1 successful). Of 16 nests monitored for edge-tolerant species, 11 successfully fledged young.

As expected, edge-tolerant species like the rufous-sided towhee reproduce very well in the dense understory and midstory vegetation that often develops following a Moderate or Maximum Crop Tree Management treatment.

SUMMARY

Forest-interior species had more than twice as many territories in harvested areas as they did in unharvested areas. Edge-tolerant species had more than three times as many territories in harvested habitat. Of the harvested plots, the traditional thinning had the fewest territories (forest-interior and edge-tolerant), and the Moderate Crop Tree Management treatment had the most. Landowners interested in having a variety of bird species on their property should consider crop tree management prescriptions to help attain that goal.

Note: This article was summarized from information found in BREEDING BIRD USE OF CROP TREE RELEASE HARVESTS, COOPER'S ROCK STATE FOREST, WEST VIRGINIA by Petra Bohall Wood, West Virginia University; John B. Churchill, West Virginia University; and Toni McClellan, USDA Forest Service, Northeastern Area, State and Private Forestry; in press.

Estimating Costs for Precommercial Silvicultural Treatments in the Northeast

by Arlyn W. Perkey

In 1982, Burl S. Ashley authored "TSI Cost Computations, Guidelines," which replaced "Guidelines for TSI Cost Computations," 1975. The following tables and formulas are an update of the 1982 tables using current wage rates and herbicide costs. Equations were developed that approximate the contents of the 1982 Cost Per Square Foot of Basal Area Tables. These equations provide the user with the option of obtaining a more specific answer for a given set of labor, herbicide, and carrier costs. Some tables are printed to provide the user with the flexibility of applying the information when a calculator is not readily available. The tables also display the cost estimates Per Diameter Inch, a means of applying the information for those who are less familiar with basal area.

Since it is now much more common to use water soluble herbicides in silvicultural treatments, the method of applying these costs has been adjusted to provide the flexibility of having water as a carrier at no cost. Also, non-petroleum based carriers are now available, and they provide a viable option to fuel oil that was frequently used as a carrier in 1982. Non-petroleum based carriers are generally regarded as more environmentally friendly.

What has not changed is that these costs are based on the same wide range of averages that Burl Ashley used in 1982. His basis was data gathered in the field during actual timber stand improvement operations and the average of various research results. The method of application was principally the axe and hand sprayer. The costs involve all time expended to carry out the operation beginning with the departure from the farmstead and ending at the time of return to that point. Most of the estimates are based on relatively inexperienced personnel performing the procedures. Planned operations conducted by trained and experienced workers would require less time.

A hand ax and hand sprayer are inexpensive, readily-available tools landowners can easily operate to accomplish silvicultural treatments.

The amount of herbicide used in a silvicultural treatment should be the amount shown on the label. Being too conservative and using less may result in poor results that require additional, costly treatment. Using too much herbicide can increase the risk of damaging or killing untargeted trees through root grafts or movement in the soil. Herbicides vary regarding their persistence, movement in the soil, and movement through root grafts. **Read and follow the label carefully.**

Deadening wild grapevines is sometimes a greater challenge than killing undesirable trees. Time and cost figures for deadening a vine less than four inches in diameter is about the same as for killing a 4-inch tree. It is appropriate to use the diameter inch cost computation method to determine grapevine deadening costs. To do this, each vine smaller than four inches should be tallied as four inches; larger ones should be tallied according to their actual diameter. When estimating tree-deadening costs with the basal area method, a separate diameter inch grapevine tally should be considered. The point sample center can be used as a 1/10-acre plot center.

USE OF TABLES I-VIII OR RELATED EQUATIONS TO ESTIMATE TREATMENT COSTS

To estimate the cost of doing precommercial silvicultural practices using herbicides, you need the following information:

- Price of herbicide per gallon
- Cost of carrier per gallon
- Appropriate quantity of carrier to mix with herbicide
- Hourly wage rate of applicator
- Size of the trees to be deadened

Combine that price, quantity, and size information with the following coefficients for trees of various size classes.

D.B.H. (inches)	X	Y
2	0.015	0.82
4	0.017	0.3875
6	0.017	0.2475
8	0.017	0.1775
10	0.017	0.1375
12	0.017	0.1075
14	0.017	0.0875
16	0.017	0.07
18	0.017	0.06
20	0.016	0.0575

The cost of equipment, herbicide, and carrier is relatively small compared to the cost of labor required to deliver the product to the tree.

Use the following equations to calculate the cost of deadening trees per square foot of basal area.

Equation 1:

$G = H+QC$

Where

G = total cost of mixing one gallon of herbicide
H = cost of the herbicide per gallon
Q = quantity of water, vegetable oil, fuel oil or other carrier in gallons to be mixed with 1 gallon of herbicide
C = cost of the carrier per gallon (may be zero)

Equation 2:

$M = G/(1 + Q)$

Where

M = cost per gallon of herbicide mixture, ready to apply
G = total cost of mixing 1 gallon of herbicide
Q = number of gallons of carrier to mix with 1 gallon of herbicide

Equation 3:

$T = WY+MX$

Where

T = total cost of the application work per square foot of basal area for a given size class
W = hourly wage rate of applicator ($/hr.)
M = cost per gallon of the herbicide mixture, ready to apply
Y = time required to treat 1 square foot of basal area of trees in a given diameter class
X = quantity of herbicide mixture required to treat 1 square foot of basal area of trees in a given diameter class

USING THE EQUATIONS AND CONVERTING COSTS FROM SQUARE FOOT OF BASAL AREA TO DIAMETER INCH

The cost of herbicide (H) is $60/gallon. It is mixed with 1 gallon of water as a carrier (at no cost). The hourly wage rate of the applicator is $10/hour. The size of the trees to be deadened is 10 inches dbh. What is the cost of deadening these trees per square foot of basal area? What is the cost of deadening them per diameter inch?

From Equation 1:

$G = H+QC$
$G = \$60+1(0) = \$60$

From Equation 2:

$$M = G/(1+Q)$$
$$M = \$60/(1+1) = \$30$$

From Equation 3:

$$T = WY+MX$$
$$T = \$10(.1375)+\$30(.017) = \$\ 1.89 \text{ per square foot of basal area}$$

To answer the second question, information in the following table is used to convert costs from square foot of basal area to diameter inch.

Diameter	Basal Area	Trees/1 square foot	Dia. In./sq.ft.
2	.022	45.45	90.9
4	.087	11.49	46.0
6	.196	5.10	30.6
8	.349	2.87	23.0
10	.545	1.83	18.3
12	.785	1.27	15.2
14	1.069	.94	13.2
16	1.396	.72	11.5
18	1.767	.57	10.3
20	2.181	.46	9.2

The trees to be deadened are 10 inches in diameter. Therefore,

$1.89/sq. ft. divided by 18.3 diameter inches/sq.ft. = $0.103 per diameter inch.

Tables I, III, V, and VII are based on calculations made from the above equations. Tables II, IV, VI, and VIII are derived by converting cost per square foot of basal area to cost per diameter inch as shown above.

After the herbicide is mixed with a carrier, it should be placed in a sturdy container and labeled to avoid confusion.

TABLE I

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $20.00 per gallon)

D.B.H. (inches)	Hourly Labor Rate $8.00	$10.00	$12.00	$14.00	$16.00
2	6.86	8.50	10.14	11.78	13.42
4	3.44	4.22	4.99	5.77	6.54
6	2.32	2.82	3.31	3.81	4.30
8	1.76	2.12	2.47	2.83	3.18
10	1.44	1.72	1.99	2.27	2.54
12	1.20	1.42	1.63	1.85	2.06
14	1.04	1.22	1.39	1.57	1.74
16	0.90	1.04	1.18	1.32	1.46
18	0.82	0.94	1.06	1.18	1.30
20	0.78	0.90	1.01	1.13	1.24

TABLE II

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $20.00 per gallon)

D.B.H. (inches)	Hourly Labor Rate $8.00	$10.00	$12.00	$14.00	$16.00
2	0.075	0.094	0.112	0.130	0.148
4	0.075	0.092	0.108	0.125	0.142
6	0.076	0.092	0.108	0.124	0.141
8	0.077	0.092	0.107	0.123	0.138
10	0.079	0.094	0.109	0.124	0.139
12	0.079	0.093	0.107	0.121	0.136
14	0.079	0.092	0.105	0.119	0.132
16	0.078	0.090	0.103	0.115	0.127
18	0.080	0.091	0.103	0.115	0.126
20	0.085	0.097	0.110	0.122	0.135

TABLE III

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $30.00 per gallon)

D.B.H. (inches)	Hourly Labor Rate $8.00	$10.00	$12.00	$14.00	$16.00
2	7.01	8.65	10.29	11.93	13.57
4	3.61	4.39	5.16	5.94	6.71
6	2.49	2.99	3.48	3.98	4.47
8	1.93	2.29	2.64	3.00	3.35
10	1.61	1.89	2.16	2.44	2.71
12	1.37	1.59	1.80	2.02	2.23
14	1.21	1.39	1.56	1.74	1.91
16	1.07	1.21	1.35	1.49	1.63
18	0.99	1.11	1.23	1.35	1.47
20	0.94	1.06	1.17	1.29	1.40

TABLE IV

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $30.00 per gallon)

D.B.H. (inches)	Hourly Labor Rate $8.00	$10.00	$12.00	$14.00	$16.00
2	0.077	0.095	0.113	0.131	0.149
4	0.078	0.095	0.112	0.129	0.146
6	0.081	0.098	0.114	0.130	0.146
8	0.084	0.099	0.115	0.130	0.146
10	0.088	0.103	0.118	0.133	0.148
12	0.090	0.104	0.118	0.133	0.147
14	0.092	0.105	0.118	0.131	0.145
16	0.093	0.105	0.117	0.130	0.142
18	0.096	0.108	0.119	0.131	0.143
20	0.102	0.115	0.127	0.140	0.152

TABLE V

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $40.00 per gallon)

D.B.H. (inches)	Hourly Labor Rate $8.00	$10.00	$12.00	$14.00	$16.00
2	7.16	8.80	10.44	12.08	13.72
4	3.78	4.56	5.33	6.11	6.88
6	2.66	3.16	3.65	4.15	4.64
8	2.10	2.46	2.81	3.17	3.52
10	1.78	2.06	2.33	2.61	2.88
12	1.54	1.76	1.97	2.19	2.40
14	1.38	1.56	1.73	1.91	2.08
16	1.24	1.38	1.52	1.66	1.80
18	1.16	1.28	1.40	1.52	1.64
20	1.10	1.22	1.33	1.45	1.56

TABLE VI

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $40.00 per gallon)

D.B.H. (inches)	Hourly Labor Rate $8.00	$10.00	$12.00	$14.00	$16.00
2	0.079	0.097	0.115	0.133	0.151
4	0.082	0.099	0.116	0.133	0.150
6	0.087	0.103	0.119	0.135	0.152
8	0.091	0.107	0.122	0.138	0.153
10	0.097	0.112	0.127	0.142	0.157
12	0.101	0.115	0.130	0.144	0.158
14	0.105	0.118	0.131	0.144	0.158
16	0.108	0.120	0.132	0.144	0.157
18	0.113	0.124	0.136	0.148	0.159
20	0.120	0.132	0.145	0.157	0.170

TABLE VII

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $50.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	7.31	8.95	10.59	12.23	13.87
4	3.95	4.73	5.50	6.28	7.05
6	2.83	3.33	3.82	4.32	4.81
8	2.27	2.63	2.98	3.34	3.69
10	1.95	2.23	2.50	2.78	3.05
12	1.71	1.93	2.14	2.36	2.57
14	1.55	1.73	1.90	2.08	2.25
16	1.41	1.55	1.69	1.83	1.97
18	1.33	1.45	1.57	1.69	1.81
20	1.26	1.38	1.49	1.61	1.72

TABLE VIII

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $50.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	0.080	0.098	0.117	0.135	0.153
4	0.086	0.103	0.120	0.136	0.153
6	0.092	0.109	0.125	0.141	0.157
8	0.099	0.114	0.130	0.145	0.160
10	0.107	0.122	0.137	0.152	0.167
12	0.113	0.127	0.141	0.155	0.169
14	0.117	0.131	0.144	0.157	0.170
16	0.123	0.135	0.147	0.159	0.171
18	0.129	0.141	0.152	0.164	0.176
20	0.137	0.149	0.162	0.174	0.187

EXAMPLE PROBLEM 1

Purpose: This problem is designed to help you use Equations 1 and 2 to determine the cost of herbicide mixture, and (given inventory information in diameter inches) use the appropriate table to estimate the cost of doing a silvicultural treatment.

Use the preceding equations and tables to estimate the cost of releasing 20 crop trees per acre on a 15 acre project using the inventory of trees to be deadened from 1/10th acre plots. The cost of labor is $8.00 per hour and the cost of the herbicide is $60/gallon, and it is to be mixed with water at a ratio of 1 to 1. One gallon of water is mixed with one gallon of herbicide.

Inventory information:

DBH	Dia. In./acre	Cost/dia. inch	Cost/acre
4	80		
6	240		
8	320		
10	200		
Total	840		

SOLUTION:

Use Equations 1 and 2 to determine the cost of the herbicide mixture ready to apply.

From Equation 1:

$G = H+QC$

$G = \$60+1(0)$

From Equation 2:

$M = G/(1+Q)$

$M = \$60/(1+1) = \$30$

From Table IV, $30/gallon herbicide and carrier cost table, obtain the cost per diameter inch for each respective diameter class. Multiply the diameter inches per acre to be treated times the cost per diameter inch to obtain the estimated cost of releasing the 20 crop trees per acre.

DBH	Dia. In./acre	Cost/dia. inch	Cost/acre
4	80	.078	6.24
6	240	.081	19.44
8	320	.084	26.88
10	200	.088	17.60
Total	840		$70.16

Since the project area is 15 acres:

15 acres ($70.16/acre) = $1,052.40

EXAMPLE PROBLEM 2

Purpose: This problem is designed to help you use Equations 1 and 2 to determine the cost of herbicide mixture, and (given inventory information in square feet of basal area) use Equation 3 to estimate the cost of doing a silvicultural treatment. This procedure is needed when labor and herbicide mixture costs do not coincide with parameters in a table.

Using the equations that preceded the Tables I-VIII, estimate the cost of doing the following silvicultural work. How much will it cost to do 15 acres of site preparation for natural regeneration work using herbicides to deaden interfering trees? Treated trees will be injected with herbicide using a hatchet and squirt bottle. The cost of the herbicide is $56 per gallon. Reading the label reveals the herbicide is water soluble and for this type of application it should be a 50 percent solution (mix one gallon of herbicide with one gallon of water). Your labor cost is $8.00 per hour. You have inventoried the work area, and estimated the square foot of basal area per acre to be deadened by diameter class as follows (two left columns).

DBH	Basal area/acre	Cost/sq. ft. of BA	Cost/acre
2	.5		
4	1		
6	2		
8	2.5		
10	3		
12	10		
14	14		
Total	33		

SOLUTION:

Use Equations 1-3 to calculate the cost per square foot of basal area by diameter class and the cost per acre.

From Equation 1:

G = H+QC
G = $56+1(0)

From Equation 2:

M = G/(1+Q)
M = $56/(1+1) = $28

From Equation 3:

T = WY+MX

Using X and Y values (from Table on page 17) for trees in the respective diameter classes, calculate the cost for each class:

For 10-inch dbh trees,
T = $8(.1375) + $28(.017) = $1.58
Cost/acre = 3.0 sq.ft./ac($1.58/sq.ft.) = $4.74

Following is the completed table for the diameter classes in this treatment area.

DBH	Basal area/acre	Cost/sq. ft. of BA	Cost/acre
2	.5	6.98	3.49
4	1	3.58	3.58
6	2	2.46	4.92
8	2.5	1.90	4.75
10	3	1.58	4.74
12	10	1.34	13.40
14	14	1.18	16.52
Total	33		$51.40

Since the proposed work area is 15 acres, the estimated cost of this treatment is:

15 acres ($51.40/acre) = $771

Note: When herbicides are used to do silvicultural treatments, the root systems as well as the stem are killed. Depending on the herbicide being used, nearby trees, especially of the same species, may also be affected through root grafts. When this is undesirable, managers may need a means to do treatments that does not involve the use of herbicides. Tables IX and X or the following formula may be used to estimate the cost of doing treatments in young stands.

Cost per square foot of basal area by diameter class = Labor rate (Y)

Where Y has the following respective values by diameter class:

DBH	Y
2	.81
3	.55
4	.385
5	.315
6	.245
7	.205
8	.175
9	.15
10	.135

For example, if trees to be treated are 10 inches in diameter, and the labor rate is $10/hour, the estimated cost of doing the work is:

C = .135($10) = $1.35 per square foot of BA

TABLE IX

ESTIMATED THINNING COSTS FOR YOUNG STANDS
PER SQUARE FOOT OF BASAL AREA
NO HERBICIDE

DBH	HOURLY LABOR RATE				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	6.48	8.10	9.72	11.34	12.96
3	4.40	5.50	6.60	7.70	8.80
4	3.08	3.85	4.62	5.39	6.16
5	2.52	3.15	3.78	4.41	5.04
6	1.96	2.45	2.94	3.43	3.92
7	1.64	2.05	2.46	2.87	3.28
8	1.40	1.75	2.10	2.45	2.80
9	1.20	1.50	1.80	2.10	2.40
10	1.08	1.35	1.62	1.89	2.16

TABLE X

ESTIMATED THINNING COSTS FOR YOUNG STANDS
PER DIAMETER INCH
NO HERBICIDE

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	0.071	0.089	0.107	0.125	0.143
3	0.096	0.120	0.143	0.167	0.191
4	0.101	0.126	0.151	0.176	0.201
5	0.110	0.137	0.164	0.192	0.219
6	0.107	0.134	0.161	0.187	0.214
7	0.108	0.135	0.162	0.189	0.216
8	0.106	0.133	0.159	0.186	0.212
9	0.104	0.130	0.157	0.183	0.209
10	0.105	0.131	0.157	0.183	0.210

EXAMPLE PROBLEM 3

Purpose: This problem is designed to build on what you learned in Example Problem 1 using diameter inches as the inventory parameter. It shows how to go from raw diameter-inch-inventory information to a completed cost estimate for a project.

The following tally sheet is from a one-tenth acre plot where crop trees, cut trees, and leave trees were inventoried. Normally, several plots like this would be measured to get an estimate of average

CROP TREE RELEASE TALLY SHEET

LANDOWNER: DATE: 8-22-00
STAND HISTORY: Abandoned pasture that reverted to forest
STAND NUMBER: 1 TYPE: cherry-maple AGE: 35-40 years
ACRES: 20 BAF: 1/10 acre SITE: mesic
LANDOWNER OBJECTIVES: timber income, mast for wildlife, fall foliage

Species	DBH	Ht	Crop Tree			Other Tree	
			T,W, A,WQ	FTG	#/Ac	C,L	#/Ac
BC	16		T+W	2			
RM	10					C	
BC	12					C	
RM	6					C	
SM	8					L	
SM	10					L	
SM	8					L	
BC	8					C	
SM	8					C	
SM	10		T+A	0			
SM	6					C	
SM	10					C	
RM	6					C	
SM	8		T+A	0			
WA	6					C	
BC	4					C	
SM	6					C	
WA	6					C	
WA	8					C	
WA	8		T	0			
SM	6					L	
SM	6					L	

BC - black cherry
SM - sugar maple
RM - red maple
WA - white ash

Crop Tree Categories:
T - Timber
W - Wildlife
A - Aesthetic

Other Tree Categories:
C - Cut Tree
L - Leave Tree

DBH - Diameter Breast High
Ht - Height
FTG - Free To Grow Rating (0-4)

USDA Forest Service, NA-S&PF, Morgantown, WV
(January 1993)
(from Crop Tree Management In Eastern Hardwoods)

stand conditions. For the purpose of this learning exercise, use this one plot as though it represents the average condition in this stand.

Compare the cost of releasing crop trees in this 20 acre stand using a herbicide with the cost of doing the same treatment mechanically with chain saws.

For the herbicide treatment, the chemical costs $60 per gallon and is mixed at a 1:1 ratio with water as a carrier (no cost). The labor cost to do the work is $10.00 per hour.

For the mechanical treatment, the cost of a person with a chainsaw is $10.00 per hour.

The data on the foregoing tally sheet is for one-tenth of an acre. There are four crop trees on that plot, representing 40 crop trees per acre to be released. There are an additional five leave trees (L) per acre that are not being cut because they do not interfere with a crop tree. There are 13 trees that are to be either deadened with herbicide, or cut (C). These 13 trees represent 130 trees per acre to be treated.

The following table shows the distribution of the treated trees by diameter class as it was summarized from the tally sheet and converted to a per acre basis.

DBH	Trees/acre	Dia. In./acre	Cost/dia. inch	Cost/acre
4	10	40		
6	60	360		
8	30	240		
10	20	200		
12	10	120		
Total	130	960		

The herbicide mixture is delivered into the hack made by a small hatchet on the sapling-size beech. A hatchet and commonly used herbicide is much safer for most applicators than a chainsaw.

Striped-maple that interferes with the establishment of regeneration can be treated with herbicide. Cutting this stem and not using herbicide would cause it to re-sprout and continue to inhibit the establishment of desirable tree species.

SOLUTION:

The following two tables list the cost of treatment by diameter class for each of the two methods. The number of trees per acre in each class is multiplied by the size of the tree to obtain the diameter inches per acre in each class. The diameter inches per acre is multiplied by the cost per diameter inch (obtained from Tables IV and X respectively), to obtain cost per acre by diameter class. The summation of the diameter class costs gives the total cost per acre.

COST PER ACRE BY DIAMETER CLASS FOR THE HERBICIDE METHOD

DBH	Trees/acre	Dia. In./acre	Cost/dia. inch	Cost/acre
4	10	40	.095	3.80
6	60	360	.098	35.28
8	30	240	.099	23.76
10	20	200	.103	20.60
12	10	120	.104	12.48
Total	130	960		$95.92

COST PER ACRE BY DIAMETER CLASS FOR THE MECHANICAL METHOD

DBH	Trees/acre	Dia. In./acre	Cost/dia. inch	Cost/acre
4	10	40	.126	5.04
6	60	360	.134	48.24
8	30	240	.133	31.92
10	20	200	.131	26.20
12	10	120	.131*	15.72
Total	130	960		$127.12

* cost per diameter inch was assumed to be the same as for the 10-inch class

Since this treatment area is 20 acres in size, the cost differential for these two methods on this project is as follows:

Herbicide method: $95.92 per acre (20 acres) = $1,918.40

Mechanical method: $127.12 per acre (20 acres) = $2,542.40

These cost revisions were possible with the assistance of the following individuals:

Jim Colbert, USDA Forest Service, Northeastern Research Station
Jeff Kochenderfer, West Virginia Division of Forestry
Gary Miller, USDA Forest Service, Northeastern Research Station
Jim Kochenderfer, USDA Forest Service, Northeastern Research Station

The following formula and table can be used to estimate the cost of pruning pine to a respective height.

Cost per tree per pruned height class = Labor rate (Y)

Where Y has the following respective values by diameter class:

DBH	Y
6	.053
7	.06
8	.067
9	.073
10	.08
11	.093
12	.107
13	.12
14	.135
15	.16
16	.18
17	.20

For example, when the labor rate is $10/hour, the cost of pruning pine to a height of 17 feet is:

Cost of pruning pine per tree = $10 (.20) = $2.00

ESTIMATED COST PER TREE FOR PRUNING PINE

Pruned Height (feet)	Hourly Labor Rate $8.00	$10.00	$12.00	$14.00	$16.00
6	0.42	0.53	0.64	0.74	0.85
7	0.48	0.60	0.72	0.84	0.96
8	0.54	0.67	0.80	0.94	1.07
9	0.58	0.73	0.88	1.02	1.17
10	0.64	0.80	0.96	1.12	1.28
11	0.74	0.93	1.12	1.30	1.49
12	0.86	1.07	1.28	1.50	1.71
13	0.96	1.20	1.44	1.68	1.92
14	1.08	1.35	1.62	1.89	2.16
15	1.28	1.60	1.92	2.24	2.56
16	1.44	1.80	2.16	2.52	2.88
17	1.60	2.00	2.40	2.80	3.20

Estimating the costs of doing silvicultural treatments is difficult because of the many variable factors that influence cost. The equations and tables presented provide a starting point. As experience in a local area is obtained, adjustments can be made to fit local conditions and crew experience.

* * * * * *

Aldo Leopold's Land Ethic: Is it Only Half a Loaf Unless a Consumption Ethic Accompanies It?[1] or Is the Shift to "Ecological Sustainability" on U.S. Public Lands Merely a Sophisticated "NIMBYism" Masquerading as a "Paradigm Shift"?

by Doug MacCleery, USDA Forest Service, Washington, DC

Over the last two decades there has been a substantial shift in the management emphasis of public lands, particularly federal lands, in the United States. That shift has been to a substantially increased emphasis on managing these lands for biodiversity protection and amenity values, with a corresponding reduction in commodity outputs. Over the last decade, timber harvest on National Forest lands has dropped by 70 percent, oil and gas leasing by about 40 percent, and livestock grazing by at least 10 percent.

Terms like "ecosystem management," an "ecological approach to management," and, more recently, "ecological sustainability" have been used to describe this change in the management emphasis of public lands. Many have referred to it as a significant "paradigm shift." Just recently, a Committee of Scientists issued a report proposing that the National Forests be managed for "ecological sustainability," where primary management emphasis is to be placed on "what is left" out on the land, rather than "what is removed." Commodity outputs, if they are produced, would become a derivative or consequence of managing National forests for primarily a biodiversity protection objective. Significantly, some Committee members bottomed this recommendation in part on "ethical and moral" grounds.

Many have attributed the move to ecosystem management or ecological sustainability to a belated recognition and adoption of Aldo Leopold's "land ethic"—the idea that management of land has, or should have, an ethical content. This year, celebrations are planned commemorating the 50th anniversary of the publishing of Leopold's A Sand County Almanac, in which he spoke eloquently about the need for an ethical obligation toward land use and management. One sign that Leopold's ideas have finally struck a chord with the larger society is that conservation issues are increasingly being taken up as causes of American churches.

While a mission shift on U.S. public lands is occurring in response to changing public preferences, that same public is making no corresponding shift in its commodity consumption habits. The "dirty little secret" about the shift to ecological sustainability on U.S. public lands is that, in the face of stable or increasing per capita consumption in the U.S., the effect has been to shift the burden and impacts of that consumption to ecosystems somewhere else. For example, to private lands in the U.S. or to lands of other countries.

Between 1987 and 1997, federal timber harvest dropped 70 percent, from about 13 to 4 billion board feet annually. (Note: This 9 billion board foot reduction is "log scale," which translates into about a 15 billion board foot reduction in lumber that could have been processed from it – or about one-third of U.S. annual softwood lumber production.) A significant effect of this reduction, in the face of continuing high levels of per capita wood consumption, has been to transfer harvest to private forest ecosystems in the U.S. and to forest ecosystems in Canada.

For example:

- Since 1990, U.S. softwood lumber imports from Canada rose from 12 to 18 billion board feet, increasing from 27 to 36 percent of U.S. softwood lumber consumption. Much of the increase in Canadian lumber imports has come from the native old-growth boreal forests. In Quebec alone, the export of lumber to the U.S. has tripled since 1990. The increased harvesting of the boreal forests in Quebec has become a public issue there.

- Harvesting on private lands in the southern United States also increased after the reduction of federal timber in the West. Today, the harvest of softwood timber in the southeastern U.S. exceeds the rate of growth for the first time in at least 50 years. Increased harvesting of fiber by chip mills in the southeastern U.S. has become a public issue regionally.

Today the U.S. public consumes more resources than at any time in its history, and it also consumes more per capita than almost any other nation. Since the first Earth Day in 1970, the average family size in the United States has dropped by 16 percent, while the size of the average single family house being built has increased by 48 percent.

The U.S. conservation community and the media have given scant attention to the "ecological transfer effects" of the mission shift on U.S. public lands. Any ethical or moral foundation for ecological sustainability is weak indeed unless there is a corresponding focus on the consumption side of the natural resource equation. Without such a connection, ecological sustainability on public lands is subject to challenge as just a sophisticated form of NIMBYism ("not in my back yard"), rather than a true paradigm shift.

A cynic might assert that one of the reasons for the belated adoption of Aldo Leopold's land ethic is that it has become relatively easy and painless for most of us to do so. When Leopold was a young man forming his ideas, more than 40 percent of the U.S. population lived on farms. An additional 20 percent lived in rural areas and were closely associated with the management of land. Today less than two percent of us are farmers and most of us, even those living in rural areas, are disconnected from any direct role in the management of land. Adopting a land ethic is easy for most of us today, because it imposes the primary burden "to act" on someone else.

While few of us are resource producers any more, we all remain resource consumers. This is one area we all can act upon that could have a positive effect on resource use, demand and management. Yet few of us connect our resource consumption to what must be done to the land to make it possible. At the same time many of us espouse the land ethic, our operating motto in the marketplace seems to be "shop 'till you drop" or "whoever dies with the most toys wins."

The disjunct between people as consumers and the land is reflected in rising discord and alienation between producers and consumers. Loggers, ranchers, fishermen, miners, and other resource producers have all at times felt themselves subject to scorn and ridicule by the very society that benefits from the products they produce. What is absent from much environmental discourse in the U.S. today is a recognition that urbanized society is no less dependent upon the products of forest and field than were the subsistence farmers of America's past. This is clearly reflected in the language used in such discourse. Rural communities traditionally engaged in producing timber and other natural resources for urban consumers are commonly referred to as natural resource "dependent" communities. Seldom are the truly resource dependent communities like Boulder, Denver, Detroit, or Boston ever referred to as such.

One of the relatively little known aspects of Aldo Leopold's career is the years he spent at the Forest Service's Forest Products Lab at Madison, Wisconsin. While there, he spoke of the need for responsible consumption. In 1928 Leopold wrote:

> The American public for many years has been abusing the wasteful lumberman. A public which lives in wooden houses should be careful about throwing stones at lumbermen, even wasteful ones, until it has learned how its own arbitrary demands as to kinds and qualities of lumber, help cause the waste which it decries....
>
> The long and the short of the matter is that forest conservation depends in part on intelligent consumption, as well as intelligent production of lumber.

If management of land has an ethical content, why does not consumption have a corresponding one, as well? Is there a need for a "personal consumption ethic" to go along with Leopold's land ethic? In his wonderful land ethic chapter in A Sand County Almanac, Leopold wrote that evidence that no land ethic existed at the time was that a "farmer who clears his woods off a 75 percent slope, turns his cows into the clearing, and dumps its rainfall, rocks, and soil into the community creek, is still (if otherwise decent) a respected member of society."

To take off on that theme and make it more contemporary, the evidence that no personal consumption ethic exists today is that a "suburban dweller with a small family who lives in a 4000 square-foot home, owns three or four cars, commutes to work alone in a gas guzzling sport utility vehicle (even though public transportation is available), and otherwise leads a highly resource consumptive lifestyle is still (if otherwise decent) a respected member of society. Indeed, her/his social status in the community may even be enhanced by virtue of that consumption."

*In the United States, smaller family size has **not** translated to smaller new houses. We are a very consuming society.*

Ecosystem management or ecological sustainability on public lands will have weak or non-existent ethical credentials and certainly will never be a truly holistic approach to resource management until the consumption side of the equation becomes an integral part of the solution, rather than an afterthought, as it is today. Belated adoption of Leopold's land ethic was relatively easy. The true test as to whether a paradigm shift has really occurred in the U.S. will be whether society begins to see personal consumption choices as having an ethical and environmental content as well – and then acts upon them as such.

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[1] Delivered at the conference "Building on Leopold's Legacy," sponsored by the Wisconsin Academy of Sciences, Arts and Letters in Madison, Wisconsin, on October 4-7, 1999. For more information, visit the conference website at: http://www.wisc.edu/wisacad/landethic/index.htm

Agroforestry – What Is It? Can You Benefit From It?

by

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AGROFORESTRY – THE FOUR "I'S"

You may be hearing things about agroforestry and have been wondering what it is all about. Basically agroforestry is a combination of forestry and agricultural practices applied in an intensive land management system that optimizes the benefits from the biological interactions created when trees and/or shrubs are intentionally integrated with crops and/or livestock. The combination helps create more integrated, diverse, and sustainable woodlots, farms, ranches, and rural communities. Agroforestry trees are "working trees" that will pay their own way. All they need is a little space, water, nutrients, and some maintenance.

PAST AND PRESENT

Agroforestry is not a new concept, nor is it new technology. It has been practiced around the world for hundreds of years and is most commonly associated with tropical and sub-tropical regions. Agroforestry has only been practiced in the United States since the early 1900's where permanent tree-covered systems were used to maximize production on arable lands. However, political and agricultural groups opposed the idea of changing the methods of food production, and it wasn't until the Dust Bowl in the 1930's that caused the opposing groups to reconsider. There were investigative activities up through the 1950's until the post WW II economic and industrial technology boom brought a stop to the need for tree crop projects. In the late 1960's and early 1970's, an interest in trees and their potential role in food production and soil conservation was renewed. This was because of (1) environmental and ecological concerns; (2) decreasing availability and increasing costs of fossil fuels; (3) soil erosion rates and their direct effect on food production capacities; and (4) an increase in world population and the demand for increased output. Since then, researchers and producers developed an interest in agroforestry as an alternative land use suitable for temperate regions of the United States.

When used appropriately, agroforestry practices can provide many benefits to producers, communities, and society. In particular agroforestry provides:

- Increased income
- Protection of natural resources
- Protection of crops and livestock
- Diversification to reduce economic risk
- Greenways and recreational settings
- Visual screening

AGROFORESTRY PRACTICES

There are five main agroforestry practices: ***alley cropping, windbreaks, riparian forest buffers, silvopasture,*** and ***forest farming.*** They are very flexible and can be adapted for use in most situations. There is also a category for a wide array of ***special applications***. First we'll focus on the five main practices to illustrate how each offers different benefits and can be used in different situations. Although these practices are of direct beneficial use to farmers, ranchers, and forest landowners, there are many indirect social, economic, and environmental benefits for rural communities as well.

Alley Cropping is created by growing crops or grass between rows of widely-spaced trees. High-value tree species such as black walnut, oak, and ash are commonly used as the rows, and in some cases, nut- and fruit-bearing trees are also used. Annual or perennial crops can be grown between the trees to provide income until the tree canopies close or the trees are ready for harvesting. Crops such as corn, small grains, hay, and clover have been grown in alley cropping systems. Vegetables and fruits, such as peppers and melons work well, as do flowers, herbs, and medicinal plants.

Mellons are being grown between rows of black walnut.

It is very important to choose the right trees for an alley cropping system. The chosen species need to be compatible with the site, satisfy landowner objectives, and have a viable product market. The spacing and orientation is also important. Rows need to be planted on the contour to maximize erosion control benefits, and wide enough to accommodate machinery as it moves between rows.

Benefits of alley cropping include:

- Diversity of farm products, increased income, improved cash flow
- Reduction of surface water runoff and erosion
- Improved utilization of nutrients
- Improved crop production through macroclimate modification
- Improved wildlife habitat
- Enhanced aesthetics

Windbreaks use trees to control wind to protect crops, homes, farmsteads, and increase crop production. Windbreaks have also been applied to protect roads from crosswinds and blowing snow, provide buffers in the urban/rural interface, and protect and/or buffer communities. As a buffer zone, they reduce noise and dust, and decrease energy consumption for heating and cooling. They also provide timber, wildlife travel lanes, and serve as a living fence.

The function of a windbreak will often dictate how it's designed and placed. Usually the tree rows are located at right angles to the prevailing wind direction. Field, livestock and farmstead wind-

breaks usually consist of two to five rows of trees and shrubs depending on the intended objective and landscape characteristics. Densities of 40 to 60 percent provide the greatest downwind protection compared to a completely solid barrier. The downwind area protected by the windbreak will extend a distance of 10 to 20 times the height of the trees. As the wind blows against the windbreak, air pressure builds up on the windward side, and large quantities of air move up and over the top or around the ends of the windbreak. The reduction in wind velocity leads to a change in the microclimate within the protected zone. Temperature and humidity levels usually increase, thus decreasing evaporation and plant water loss. Crop yields are increased by as much as 20 percent for an entire field. Livestock windbreaks are designed to provide protection during late fall, winter, and early spring. By reducing wind speed, animals are less stressed, feed more, and are healthier.

Windbreaks protect crops on the Great Plains.

The most cost effective use of windbreaks is to control blowing and drifting snow by installing living snow fences. Reduction of snow plowing costs, fewer road closures, and fewer accidents exceed the cost of establishing living snow fences by an average of 17 to 1. Traditionally the most extensive use of ranch and farmstead windbreaks in the United States has been in the Western, North Central, and Great Plains regions. However, windbreak use for privacy screens, dust control, noise reduction, and unwelcome sights, sounds, and odors has become important to communities, developments, and individual homesteads. Protection of homes and buildings is also a sure way to reduce energy costs associated with heating and cooling.

Benefits of windbreaks include:

- Increased crop yield by reducing runoff, erosion, drying winds, and increased moisture
- Wildlife habitat
- Income from timber, nuts, and/or other specialty products
- Reduction of noise, improve aesthetics, provide energy savings
- Protection of livestock, homes, buildings, equipment, and roads

Riparian forest buffers are composed of trees, shrubs, or grass planted or managed along streams, lakes, wetlands, ponds, and drainage ditches. They serve as protective barriers against the negative impacts of activities originating from adjacent land-use practices, such as agriculture, urban or industrial uses. Riparian forest buffers have been shown to reduce nitrogen runoff, protect floodplains, reduce streambank erosion, enhance aquatic environments, and protect wildlife habitat. They also trap sediment that contains animal wastes, pesticides, pathogens, and other pollutants. In some cases they provide harvestable products and function as windbreaks.

Trees and shrubs in the buffer can be harvested for specialty products. For example, nut- and fruit-bearing trees, timber trees, or berry- and floral-producing shrubs can be planted and produce a commodity crop to provide landowner income while functioning as a pollution control system. In this way, buffer systems can be adjusted to meet landowner objectives and perform the desired function by adjusting plant material composition, width, and maintenance activities. The design of the buffer is usually determined by variables such as land characteristics, objectives and desired function (conservation, production, or both), current land use, and capacity for maintenance (low intensity versus high intensity).

This riparian buffer filters sediment and excess nutrients from the adjacent agricultural field.

Riparian forest buffers are usually established concurrently with other practices as part of a conservation management system. Excluding grazing or livestock access is vital to ensure the survival and functioning of the buffer.

Benefits of riparian forest buffers include:

- Increased infiltration
- Reduced bank erosion, runoff, sediments, chemicals, and nutrients
- Wildlife habitat and travel corridors
- Production of timber and specialty products
- Enhancement of aquatic environment
- Decreased flood flows and protection of floodplains

A ***silvopasture system*** is an intentional combination of trees with forage and livestock production. The trees are managed for high-value sawlogs or nuts, and provide shade and shelter for livestock. Some nut and fruit orchards and Christmas tree plantings may also be grazed to provide added income. Many coniferous woodlands in the South and West, and a few selected hardwood plantations can be transformed into tree/forage systems. By selectively removing or harvesting the correct number of trees, enough light will reach the ground to allow forage growth under the tree canopy. Residual trees will grow faster and have an increased value. Proper livestock grazing or haying of the forages allow for annual returns while trees mature. Alternatively, trees can be planted within existing pastures. Whichever method is used to establish the system, protecting trees from livestock damage is vital, and timing of grazing and length of time the animals are kept in the trees is carefully planned.

It is important to point out that grazing can be detrimental to many hardwood forests and woodlots. **We are not advocating that livestock be turned loose in forests**. The silvopasture systems use must be carefully designed and monitored to produce successful results.

Benefits of silvopasture systems include:

- Erosion reduction
- Improved nutrient utilization/distribution and soil organic matter
- Additional income
- Diversification of farm operation
- Possible improvement of timber production in some intensively managed situations

Southern pine silvopasture system in northern Louisiana.

In a ***forest farming*** operation, high-value specialty crops are cultivated under the protection of a forest canopy. These are usually high-value specialty product items derived from green plants, fungi, invertebrates, and other organisms that inhabit forested areas. These products fall into four general categories:

- food (example, mushrooms and nuts)
- botanicals (example, herbs and medicinals)
- decoratives (example, floral greenery and dyes)
- handicrafts (example, baskets and wood products)

Shiitake mushrooms being cultivated on oak logs.

High-value crops like ginseng, shiitake mushrooms, or decorative ferns are sold for medicinal, culinary or ornamental uses. Trees may be retained indefinitely to provide appropriate microenvironment for a series of specialty crops, or mature trees can be harvested for their timber value. Forest farming is a practice that can add much needed diversity to a forest landowner, or a farming or ranching operation. The key factors are that the production system must be intentionally created and intensely managed. Examples include: maple syrup production, medicinal plants (ginseng, golden seal, black cohosh), craft materials (grasses, burls, pine cones, seed pods, evergreen cuttings), mushrooms, native fruits (persimmon, paw paw), and nuts (black walnut, pecan, hazelnut). Removal of some trees may be necessary to create the appropriate shade conditions.

Benefits of forest farming practices include:

- Increased income and diversity
- Cost effective method of TSI
- Support of local economies
- Watershed protection
- Wildlife habitat

Special applications are tree and shrub plantings that may be used to help solve special landowners concerns, such as disposal of animal wastes and filtering irrigation water, while at the same time producing short or long-rotation woody crops. Other examples include reduced damage to crop fields in floodplains by installing waterbreaks to trap debris and sediment from floods, and designing wildlife habitats that maximize the populations of various game and non-game species for landowner enjoyment or income from fee hunters or wildlife watchers. Special multi-row "timberbelts" can be managed both to protect crops, livestock, or homesteads and to produce hardwood timber for short-rotation wood crops for fuel or fiber.

Short rotation woody crops provide additional income opportunities in places where markets exist for wood pulp or fiber. In this example, wide "timberbelts" of fast-growing hybrid poplars are planted. They serve the purpose of a field windbreak during their 5- to 12-year rotation.

CONSIDERATIONS

It is important to remember that an agroforestry practice is intentional and intensive. It is done for a reason, and it requires a plan and work to establish and manage it. It is neither for every landowner nor every woodlot or field on a farm, but nearly every landowner could benefit from some type of agroforestry practice.

Agroforestry benefits come from the biological interactions caused by the planned integration of woody vegetation with crops and livestock. A properly designed and installed agroforestry practice will provide environmental and economic benefits. Many times the economic benefits of an agroforestry practice come from increased crop yields, specialty products, livestock growth, reduced energy costs, and increased forage production. The introduction of woody vegetation increases production and reduces costs.

Agroforestry practices can also produce income from the sale of products. This income can diversify income and help keep woodlands and farms profitable, especially the small family farm. Trees, shrubs, and herbaceous material can be produced in various agroforestry practices. The sale of products from these plants depends on the local markets. Landowners must evaluate the market to be sure they can produce the quantity and quality of product needed by the market.

Agroforestry practices concurrently produce economic and environmental benefits. It is the combination of these benefits that makes agroforestry so powerful and so challenging. It cannot be fully understood by a single scientific discipline. Because it is the integration of different plants that makes an agroforestry practice, it is the integration of different disciplines in the design and installation of agroforestry practices that maximizes economic and environmental benefits. Foresters, agronomists, wildlife biologists, soil scientists, and marketing specialists working together produce the best agroforestry practices.

FUTURE

Opportunities for the application of agroforestry technologies are unlimited. Currently, millions of acres of marginal and environmentally sensitive lands could be put to sustainable use using agroforestry technologies. Even productive lands could provide additional income to landowners using various agroforestry practices.

Agroforestry systems need to be blended and balanced with other technologies to attain sustainability goals. Integrated into forestland, ranch, or farm operations, these technologies can create and enhance desirable functions and outcomes essential for sustainability, income diversity, wildlife habitat, resource protection, and productivity enhancement.

ADDITIONAL INFORMATION

Publications, brochures, and fact sheets are available at the National Agroforestry Center in Lincoln, NE. The web site address is: http://www.unl.edu/nac

Cooperative Extension can provide assistance on planning or budgeting.

Any other questions contact:

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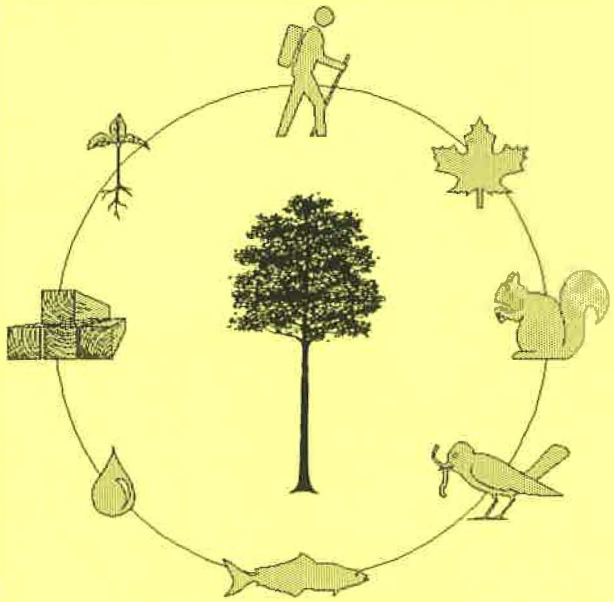
NORTHEASTERN AREA
State and Private Forestry

FOREST RESOURCES MANAGEMENT



Managing the forest for:

- *recreation*
- *aesthetics*
- *wildlife & fisheries*
- *water quality*
- *forest products*
- *soil productivity*

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